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Note on Pressure Oscillations Over South Africa

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ABSTRACT—Surface and 500-mb pressure series based on 12- and 24-hourly observations for 1958, 1966, 1965–66, and 1965–69 are analyzed for several South African stations. Preferential pressure fluctuations with periods of about 6 days are best-developed over southern and eastern coastal regions and are shown to advance from Cape Town to areas northwest of Durban at rates in good agreement with synoptic experience.

1. INTRODUCTION

The study of wave disturbances in the general circulation of the atmosphere has been well documented. Rather than occurring as random disturbances, atmospheric waves may exhibit periodic characteristics. That this is so in middle latitudes has been pointed out many times (Saltzman 1957, Saltzman and Peixoto 1957, Lahey et al. 1958, Van Mieghem 1961, Saltzman and Fleischer 1961, Shapiro and Ward 1963, Arai 1965, and others). Low-latitude information is also accumulating that shows the periodic nature of the equatorial easterlies. Rosenthal (1960) has reported a 4-day maximum meridional wind spectra and a 6-day peak in zonal wind spectra. A 4- to 5-day disturbance has been observed by Yanai et al. (1968) and by Wallace and Chang (1969), while Madden and Julian (1971) have found a 40- to 50-day oscillation in the zonal wind of the tropical Pacific. In middle latitudes, Namias (1954) has related a 10-day periodicity to midtropospheric waves. Landsberg et al. (1959) ascribed fluctuations of 3, 5–7, and 15–25 days to fast-moving waves, cyclonic disturbances, and Rossby waves, respectively. Kung (1966) and Soong and Kung (1969) have shown that kinetic energy outflow associated with traveling waves over North America occurs with highest statistical significance at 2- to 4-, 19- to 20-, and 36- to 40-day periods.

Located between latitudes 22° and 35°S, much of South Africa is geographically situated within a latitudinal zone that is critically affected by the seasonal meridional shift of the mean position of the subtropical high-pressure belt (Taljaard 1953). This is demonstrated by the seasonal fluctuation in cyclonic disturbances within these latitudes. In contrast to the summer months, during which cyclone activity is minimal, winter cyclogenesis occurs in subtropical latitudes in the Atlantic Ocean (Taljaard and van Loon 1962) and the trailing cold fronts of these west-northwest–east-southeast moving disturbances frequently pass over South Africa (Taljaard et al. 1961). The passage of these disturbances over an area dominated by a well-defined seasonal regime is complicated by the topography of the country, with its relatively narrow coastal belt backed by an abrupt escarpment and 1300-m high veld plateau. Nonetheless, a continuous procession of small-scale, low-pressure systems move from west to east around the coast of South Africa. While Anderssen (1965), van Loon (1967*a*, 1967*b*), van Loon et al. (1968) and van Loon et al. (1972) have considered aspects of large-scale, long-wave motion in the atmosphere in the Southern Hemisphere in the vicinity of southern Africa, they have not been concerned with the spectral distribution of daily pressure fluctuations at specific locations on the subcontinent. It is to this and related topics that attention is directed in this paper.

2. DATA

The study was based upon the analysis of surface pressure records observed over the period 1965–69 at 16 stations in South Africa and Southwest Africa (fig. 1). Three separate data arrays were used. They consisted of surface pressure observations at 0600 and 1800 GMT during 1966 for 14 coastal stations from Walvis Bay to Lourenco Marques, daily 1200 GMT surface pressure, and 500-mb height observations for Cape Town, Durban, Bloemfontein, and Pretoria for the period 1965–66, and daily 1200 GMT surface pressure observations at Cape Town and Durban for the period 1965–69. Spectral distributions of pressure fluctuations were based on the analysis of unfiltered series using the autocorrelation method outlined by Panofsky and Brier [1963]. Disturbance travel times were estimated by cross-spectral analysis of the Cape Town data with that of the remaining stations to the east, respectively.

3. DATA ANALYSIS

Spectral analysis of 1966 surface pressure for 14 coastal stations suggests the preferential occurrence of short-period pressure oscillations on the southern and eastern coasts of South Africa (fig. 1). All stations from the southwestern Cape to Lourenco Marques exhibit a clear 6-day peak in their pressure spectra. Alexander Bay also shows this peak. By contrast, the fluctuation with a period of about 6 days appears to shift toward 4 days north of Alexander Bay. The 3-day peak that is present

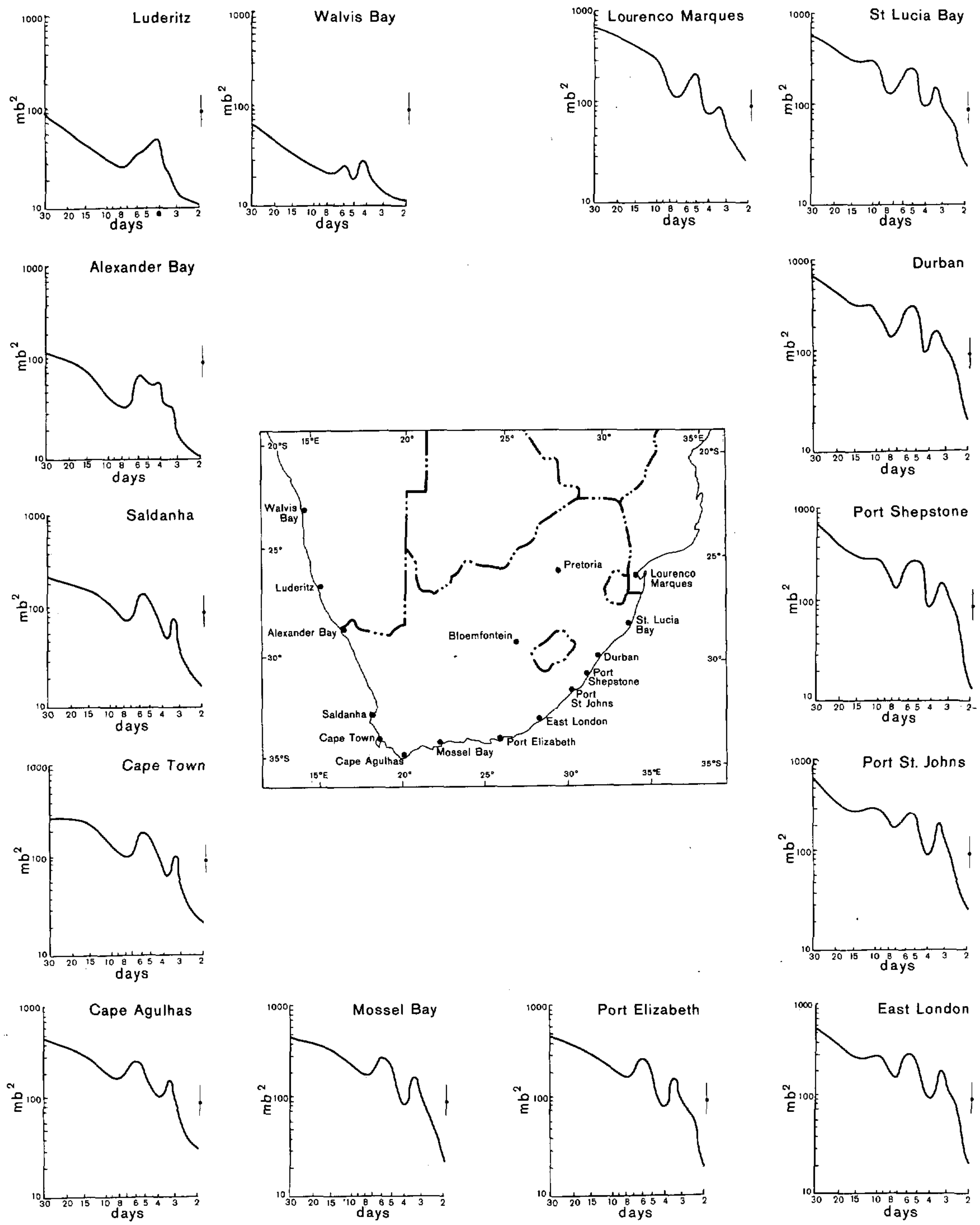

FIGURE 1.—Surface pressure spectra for stations on the coast of South Africa (period of record 1966, 0600 and 1800 GMT observations, $N=760$, $m=30$). The ordinate scale gives spectral density, the abscissa gives period. The use of a logarithmic ordinate permits the 95-percent confidence limit to be represented by a constant interval about the spectral estimate (Jenkins and Watts 1969).

in many of the spectra is difficult to explain and appears to have no synoptic counterpart. Little physical significance can be attached to it.

Cospectra between Cape Town and east coast stations show peaks in the 1966 data in the 5- to 6-day range. Table 1 gives the time lag between pressure fluctuations at Cape Town and the remaining east coast stations. The disturbance passage times appear to be in reasonable agreement with synoptic experience.

Synoptic disturbances occur more frequently over the coastal and adjacent inland areas than over the elevated plateau regions because of the circumcoastal passage of shallow coastal Lows, which appear to be little affected by seasonal pressure fluctuations. During 1966, pressure troughs that either exceeded 2 mb at sea level or caused a 20-m fluctuation in the 850-mb pressure surface over the plateau occurred with a mean frequency per month of 5.4 at Cape Town and Durban and 3.8 at Bloemfontein (table 2). These subjectively derived frequencies agree well with the values of 5.0 and 6.0 suggested by figure 1 for Cape Town and Durban.

It is not possible to make any deductions concerning the height dependency of fluctuations determined from the 1966 12-hourly pressure observations, since the latter

TABLE 1.—*Lag between the 5- to 6-day pressure oscillation at Cape Town and east coast stations*

Station	Direct distance (km)	Lag (days)
Cape Town:		
—Cape Agulhas	170	0.5
—Mossel Bay	330	0.7
—Port Elizabeth	650	1.2
—East London	820	1.5
—Port St. Johns	1060	1.7
—Port Shepstone	1160	1.9
—Durban	1260	2.1
—St. Lucia Bay	1430	2.7
—Lourenco Marques	1580	2.8

TABLE 2.—*Synoptic frequency of disturbances during 1966*

	J	F	M	A	M	J	J	A	S	O	N	D	Annual Average
Cape Town	6	5	7	4	5	4	6	5	6	6	5	6	5.4
Durban	6	6	5	4	5	5	5	6	5	7	7	4	5.4
Bloemfontein	4	4	3	3	2	3	6	5	5	5	2	4	3.8

were available only for the surface. However, analysis of 24-hourly observations at both the surface and 500 mb over the period 1965–66 for the four stations does allow the depth of the fluctuations to be roughly assessed (fig. 2A). At Cape Town, a peak in spectral density is evident around 6.0 days at both the surface and 500 mb. Over Durban, the peak is pronounced at the surface but absent at 500 mb. Unlike their coastal counterparts, the surface spectra for the plateau stations, Bloemfontein and Pretoria, are featureless and show almost uniform decreases in spectral density with increasing frequency. Though not as featureless as their surface counterparts, the 500-mb spectra for the plateau stations show little by way of significant fluctuations.

Over the 5-yr period 1965–69, 6- to 8-day peaks are clearly evident in the Cape Town and Durban daily surface pressure spectra (fig. 2B). Based on 24-hourly pressure observations, the cospectral time lag between the 6-day fluctuations at Cape Town and Durban is 1.0 day by contrast to the value of 2.1 days suggested by the analysis of the 12-hourly data of 1966.

The occurrence of pressure fluctuations around South Africa with periods of about 6 days is further illustrated by the analysis of the spatial distribution of variance associated with these fluctuations. Submitting 1958 IGY pressures [South African Weather Bureau 1960] to harmonic analysis, we computed 182 harmonics for each 10° gridpoint intersection. Thereafter, the variance accounted for by the harmonics with periods in the ranges 6–8 days was summed (fig. 3). At the surface, a strong gradient of variance was evident over South Africa with maxima occurring to the southwest and southeast of the subcontinent. At 500 mb, the variance distribution was more uniform though essentially unchanged with respect to the position of the maxima.

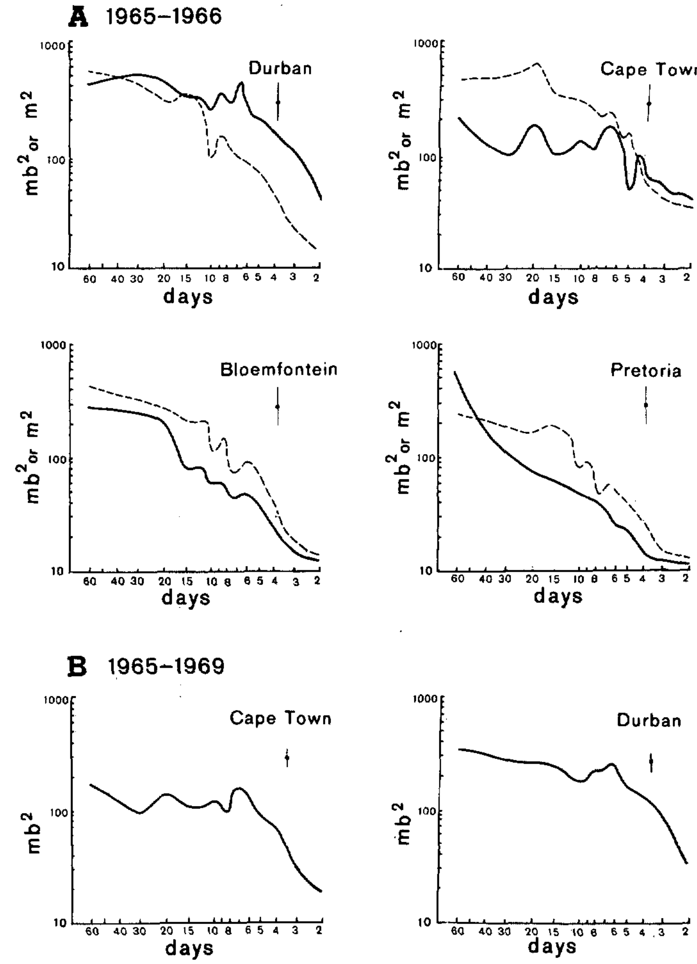

FIGURE 2.—(A) spectra of surface pressure (solid line) and 500-mb height (broken line) for Cape Town, Durban, Bloemfontein, and Pretoria (period of record 1965–66, 1200 GMT observations, N=720, m=30) and (B) spectra of surface pressure for Cape Town and Durban (period of record 1965–69, 1200 GMT observations, N=1825, m=30). Confidence limits, ordinate, and abscissa are same as figure 1.

4. CONCLUSIONS

The occurrence of clear 6-day peaks in the variance spectra of 12-hourly pressure series for 1966 at 11 stations situated on the south and east coasts of South Africa provides evidence to support a quasi-periodic fluctuation of the atmospheric circulation over the South Atlantic and Indian Oceans with a period of about 6 days. Making the a priori assumption that the Fourier decomposition of pressure series relates to specific traveling disturbances, the rate at which specific disturbances traverse the country can be determined. The results of such computations are in agreement with synoptic experience.

From the analysis of 24-hourly data over the 2-yr period 1965–66, both at the surface and 500 mb, the occurrence of the approximately 6-day fluctuation is confirmed. The surface pressure spectra for Cape Town and Durban over the 5-yr period 1965–69 are consistent with those for shorter periods of observation and are in agreement with the spatial distribution of the approximately weekly fluctuation suggested by the analysis of the IGY data.

That the approximately 6-day fluctuation is to be

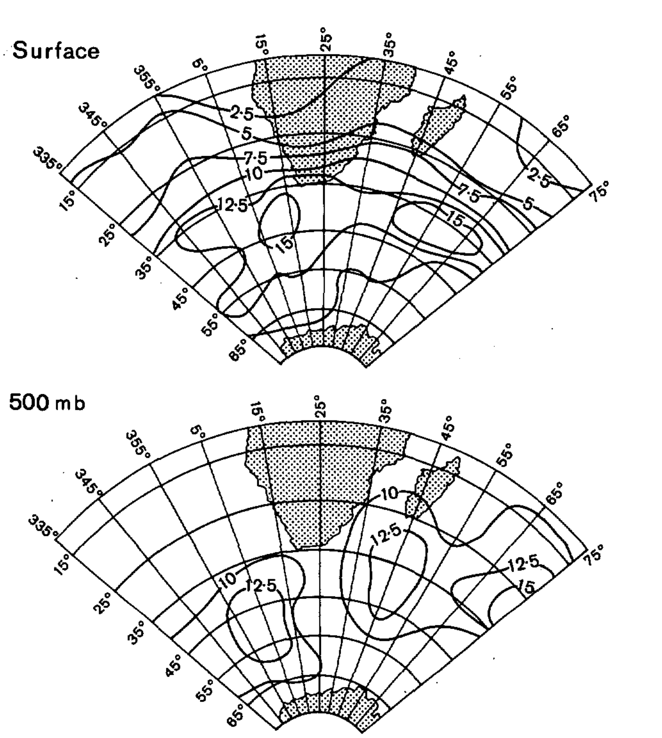

FIGURE 3.—The spatial variation of percentage variance associated with 6- to 8-day pressure fluctuations during 1958 for surface and 500-mb levels.

equated with traveling disturbances in the westerlies appears to be in little doubt. To what extent the ubiquitous coastal Lows amplify the pressure oscillation is, however, difficult to determine.

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PICTURE OF THE MONTH
Snow Covers the Southland

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The NOAA 2 VHRR (visible) data of Feb. 10 and 11, 1973 reveal, in detail, the structure of a major storm along with the resulting snow cover over the southeastern United States. On the morning of Feb. 10, 1973, a record-breaking snow storm was centered approximately 200 mi east of the Georgia/South Carolina coast (fig. 1). Numerous clusters of intense convective clouds were over Georgia, North Carolina, and South Carolina. These convective clouds are easily identifiable over northeast Georgia and South Carolina; however, over North Carolina they become somewhat masked by a higher cirrus canopy. These convective areas produced numerous reports of moderate to heavy snow and ice pellets, in addition to occasional thunder and hail. The cirrus sheet associated with the storm extended as far north as central New England, where it became very thin and tenuous (see A, fig. 1). An area of *light snow showers* can be seen over northwestern Pennsylvania and upstate New York, to the lee of Lake Ontario; the darker-appearing Finger Lakes stand out in sharp contrast to the surrounding snow-covered terrain.

On Feb. 11, 1973, the resulting swath of snow extended from south-central Alabama northeastward to southeastern Virginia (fig. 2). The sharp cutoff between snow and no snow is evident. Greatest amounts of snow appear

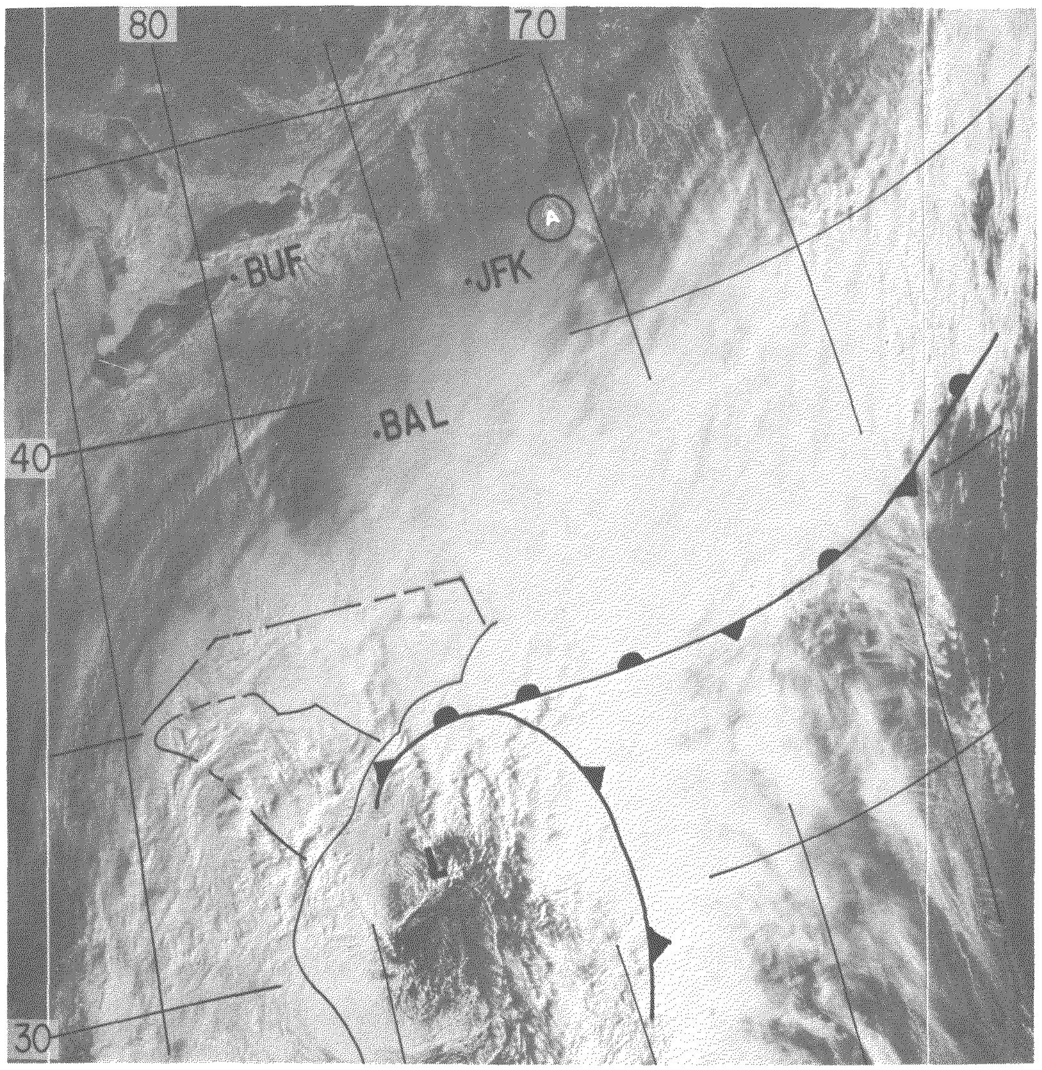

FIGURE 1.—NOAA-2 very high resolution radiometer (VHRR) image, Feb. 10, 1973, 1330 GMT.

brighter in the central portion of the overall snow area from southwestern Georgia, through central South Carolina and eastern North Carolina. Lakes, rivers, and pine forests appear black within the snow field.

In addition to the snow cover over the Southeast, clear skies permit widespread observation of an extensive snow cover from New England to Wisconsin (fig. 2). The northeast-southwest cloud lines over Lake Ontario are oriented nearly parallel to a northeasterly, low-level wind flow over the lake. Some snow showers were occurring to the lee of Lake Ontario at picture time. Scattered cirrus was over portions of Tennessee (see B, fig. 2) while an extensive deck of low cloudiness covers eastern Florida (see C, fig. 2).

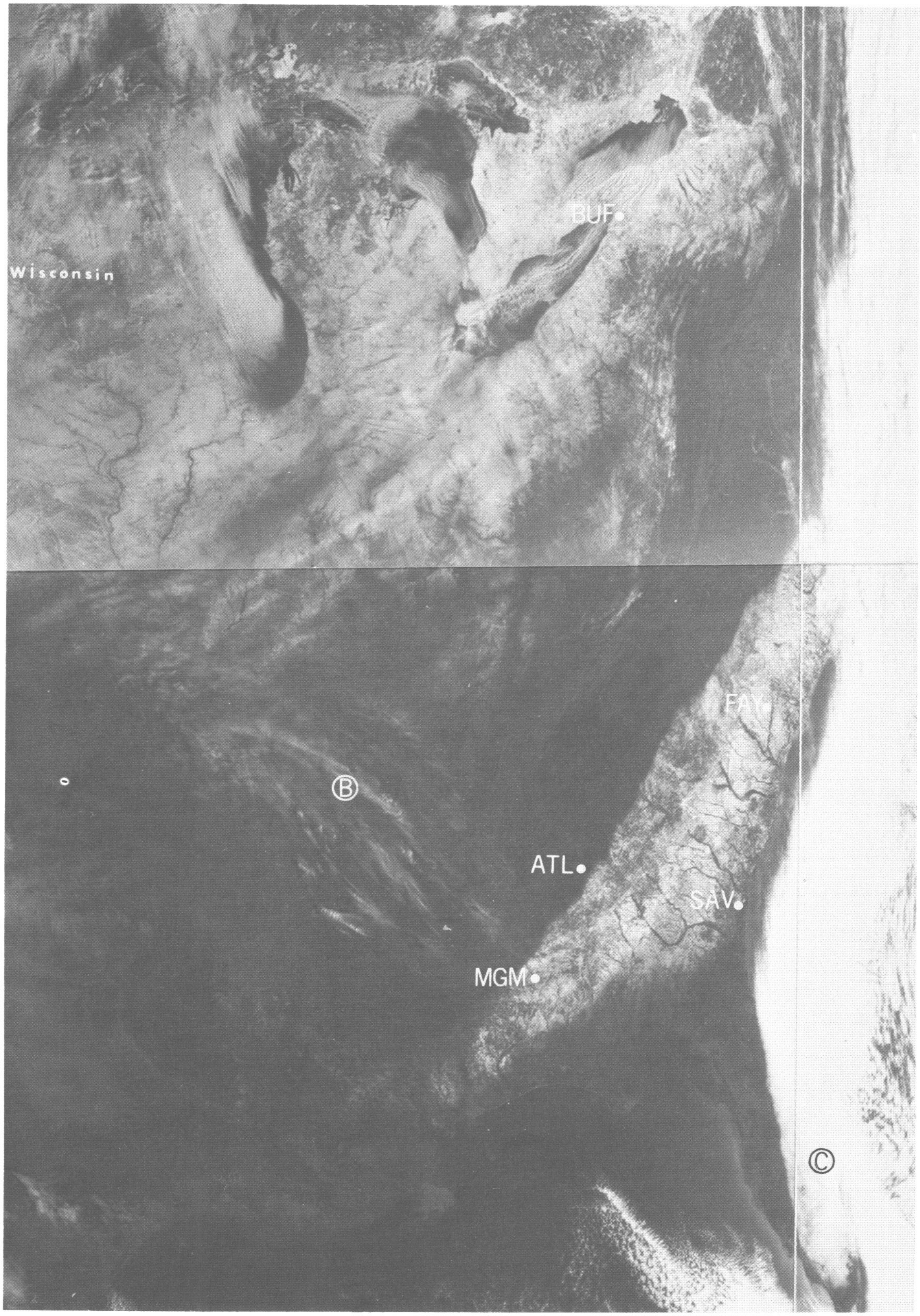

FIGURE 2.—NOAA-2 VHRR image, Feb. 11, 1973, 1500 GMT.